



Genetic diversity in rare versus common breeds of the horse

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Background

One of the major concerns in the conservation of rare breeds is loss of genetic diversity. Small population size is clearly associated with loss of genetic variability, however, the demographic histories of breeds can be quite different. Some breeds have only become rare in recent generations while breeds with current large population size may have originated from a small number of founders. In this study we examine genetic diversity in horse breeds of different conservation status to determine if there is a current difference in genetic diversity based upon level of risk.



Akhal Teke



Caspian



Canadian Horse



Cleveland Bay



Exmoor Pony

Materials and Methods

Genetic variation was examined for 30 different breeds using equine microsatellite loci. The DNA typing panel consisted of 15 microsatellites: *AHT4*, *AHT5*, *ASB2*, *HMS2*, *HMS3*, *HMS6*, *HMS7*, *HTG4*, *HTG6*, *HTG7*, *HTG10*, *VHL20*, *ASB17*, *ASB23* and *LEX33*. Amplification of microsatellites in multiple PCR reactions was performed in 25µl total volume reactions containing 50 ng of genomic DNA, 0.07 to 0.8 pmol of primers, 1xPCR buffer, 2.5mM MgCl₂, 0.2 mM dNTPs and IU AmpliTaq. For microsatellite amplification, a hot start procedure was used. Reaction products were analyzed using ABI 377 DNA sequencer. Fragment sizes were determined using the computer software STRand.

Breeds were classified based upon conservation status according to FAO or American Livestock Breeds Conservancy information. Breeds with a global population size estimated at more than 25,000 individuals were classified as common. Breeds with global population size of less than 10,000 were considered rare and divided into three groups: Critical – population size less than 2,000; Threatened – population size less than 5,000; and Watch – population size less than 10,000. Genetic diversity was analyzed using MolKin v3.0 (Gutierrez et al., 2005) for all 30 breeds and WEITZPro (Derban et al., 2002) but only 27 breeds were analyzed with this package due to program limitations. Diversity measures shown are observed and expected heterozygosity (Ho, He), the Caballero and Toro genetic diversity (GD), the internal diversity of the breed and mean genetic distance, the loss/gain is how much the total diversity would change by removing the breed, the Weitzman diversity (WV) and breed contribution to diversity (WMD).

Results and Discussion

The rank order of heterozygosity was not perfectly correlated with conservation status but in general, the higher values were found in the common breeds while the rare breeds showed lower levels of variation and 4 of the 7 lowest values were for the Critical listed breeds. The common breeds have the highest mean heterozygosity while the Critical rare breeds have the lowest. The breeds listed as Threatened have mean heterozygosity near that of the common breeds while the Watch group was more like the Critical group despite higher population sizes.

As noted by Caballero and Toro, 2002, their measures of diversity do not closely correlate with the Weitzman diversity. However, the mean values based upon conservation status do give similar results. The common breeds on average do not have a large impact upon overall diversity as seen by the Loss/Gain values and the Weitzman marginal diversity. The rare breeds in the Critical and Watch group have the greatest mean impact. The Threatened group have low contributions to diversity although heterozygosity is high. What is clear is that rare breeds make up a significant proportion of the total genetic diversity of this domestic species which emphasizes the need for conservation.

Table 2. Mean values of the diversity measures by conservation status.

Common breeds				Rare Critical				Rare Threatened				Rare Watch			
Variable	N	Mean	Std Dev	Variable	N	Mean	Std Dev	Variable	N	Mean	Std Dev	Variable	N	Mean	Std Dev
Ho	15	0.75992	0.038322	Ho	5	0.70834	0.041906	Ho	5	0.754059	0.033672	Ho	5	0.720351	0.035073
He	15	0.871438	0.03066	He	5	0.846037	0.027172	He	5	0.862031	0.026271	He	5	0.852578	0.036804
GD	15	0.909583	0.00049	GD	5	0.909316	0.000523	GD	5	0.909687	0.00062	GD	5	0.909146	0.000369
IntDiv	15	-0.01069	0.184775	IntDiv	5	0.061874	0.135859	IntDiv	5	-0.02004	0.077022	IntDiv	5	-0.0073	0.068183
MnDis	15	0.010958	0.18236	MnDis	5	-0.091	0.167451	MnDis	5	0.031788	0.106764	MnDis	5	-0.04047	0.097143
L/G	15	0.000266	0.053833	L/G	5	-0.02913	0.057439	L/G	5	0.011751	0.068127	L/G	5	-0.04777	0.040603
WV	12	10.85646	0.227095	WV	5	10.81169	0.124765	WV	5	10.91964	0.071502	WV	5	10.80696	0.228638
WMD	12	3.064167	2.028575	WMD	5	3.464	1.113185	WMD	5	2.5	0.638083	WMD	5	3.504	2.04073

Table 1. Diversity measures for horse breeds.

Breed	N	Status	Ho	He	GD	Internal Diversity	Mean Distance	Loss/Gain	WV	WMD
Andalusian	33	C	0.758	0.895	0.909	-0.062	0.0026	-0.00364	10.8802	2.85
Akhal Teke	84	RT	0.753	0.891	0.910	-0.123	0.1397	0.0017	10.9822	1.94
Arabian	84	C	0.698	0.881	0.909	-0.101	0.0042	-0.00589	10.8136	3.45
Caspian Pony	77	RC	0.780	0.894	0.919	-0.166	0.1724	0.0006	11.0059	1.73
Fell Pony	38	RT	0.808	0.823	0.909	0.0046	-0.138	-0.0092	10.9041	2.64
Haflinger	47	C	0.671	0.776	0.909	0.186	-0.2709	-0.00854	10.6341	5.05
Hanoverian	34	C	0.791	0.890	0.910	-0.00304	0.0049	0.00189	11.0616	1.23
Lippizan	76	RT	0.717	0.874	0.910	-0.00392	0.1006	0.00614	11.0017	1.77
Lusitano	70	C	0.742	0.893	0.910	-0.13	0.0087	-0.00431	.	.
Peruvian Paso	46	C	0.791	0.884	0.909	-0.0079	0.0023	-0.056	10.8841	2.82
Standardbred	30	C	0.768	0.852	0.910	-0.0008	0.0032	0.00236	.	.
Suffolk	100	RC	0.701	0.837	0.908	0.156	-0.2793	-0.123	10.8516	3.11
Quarter Horse	40	C	0.784	0.904	0.910	-0.00825	0.0093	0.00102	11.0065	1.73
Puerto Rican Paso Fino	62	RW	0.720	0.869	0.909	-0.00435	0.0035	-0.00089	10.957	2.17
Thoroughbred	175	C	0.784	0.858	0.910	0.566	-0.486	0.00798	10.2446	8.53
Columbian Paso Fino	30	C	0.796	0.874	0.909	-0.0029	0.00002	-0.00293	.	.
Rocky Mountain Horse	49	RW	0.756	0.899	0.910	-0.00937	0.0086	-0.00074	11.0189	1.61
Dales Pony	42	RW	0.742	0.857	0.909	-0.00222	-0.007	-0.00923	10.8497	3.12
Exmoor Pony	98	RC	0.678	0.834	0.909	0.154	-0.1745	-0.00202	10.6787	4.65
Morgan Horse	75	C	0.753	0.891	0.909	-0.121	0.0847	-0.00358	10.9383	2.33
Shetland Pony	97	C	0.754	0.876	0.910	-0.00769	0.1318	0.00548	10.9197	2.5
American Saddlebred	228	C	0.767	0.881	0.910	-0.239	0.3306	0.0912	10.9992	1.79
Cleveland Bay	58	RC	0.680	0.835	0.910	0.124	-0.0098	0.00254	10.7698	3.84
Shire	32	RC	0.702	0.829	0.909	0.00411	-0.0075	-0.00334	10.7523	3.99
Dartmoor Pony	75	RT	0.753	0.849	0.910	0.00666	0.0015	0.00816	10.8302	3.3
Highland Pony	25	RW	0.720	0.799	0.909	0.00697	-0.114	-0.00443	10.7748	3.79
Gotland Russ	64	RW	0.664	0.839	0.909	0.00533	-0.1392	-0.00859	10.4344	6.83
Trakhener	32	C	0.813	0.861	0.910	0.00368	-0.0012	0.00248	11.066	1.19
Tennessee Walker	59	C	0.729	0.856	0.910	0.0011	0.0344	0.00454	10.8296	3.3
Canadian Horse	52	RT	0.739	0.872	0.909	-0.005	0.0417	-0.00092	10.8801	2.85